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EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

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TECHNICAL SPECIFICATION

FOR THE LEP CORRECTION DIPOLE MAGNETS

The European Organization for Nuclear Research (CERN) is constructing a Large Electron Positron Storage Ring, called LEP.

The present technical specification concerns the supply of 496 dipole magnets of four different types which will correct horizontal and vertical orbit distortions in the machine arcs and acceleration regions.

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1 GENERAL ASPECTS

1.1 The LEP Project

CERN is constructing a Large Electron Positron Storage Ring (LEP) for colliding-beam experiments near its present site. This ring will be installed in an underground ring tunnel of approximately 27 km circumference, straddling the border between the Swiss Canton de Genève and the French Département de l'Ain. The first phase, which is now authorized, will involve the construction of the complete magnet and vacuum systems, and sufficient RF and auxiliary equipment to store beams of electrons and positrons up to an energy of between 50 and 60 GeV. The possible future addition of more RF and other equipment would enable the storage of beams of higher energies.

1.2 The LEP correction dipole magnets

The magnetic lattice of LEP contains:

176 dipoles for vertical orbit correction (MCV) } in the arcs
168 dipoles for horizontal orbit correction (MCH) }

and:

80 dipoles for vertical orbit correction (MCVA) } in the acceleration
64 dipoles for horizontal orbit correction (MCHA) }

regions of the machine.

Each correction dipole magnet has its own power supply and feeding cable.

The magnetic circuits of the correction dipoles are made of glued stacks of silicon-steel laminations, forming yokes of C-shaped cross-section. The quality of the field distribution at every excitation level is ensured by the close tolerances imposed on the pole geometry, the assembly of the yokes and the properties of the steel used. The magnetic circuits are of two different types, namely one common to the MCV and MCVA type magnets, and the other common to the MCH and MCHA type magnets.

The excitation coils, wound with enamelled copper wire, are impregnated with a radiation-resistant epoxy resin. The power dissipated in the coils is removed by air-cooled (magnet types MCV and MCH) or water-cooled (magnet types MCVA AND MCHA) aluminium heat sinks. The excitation coils are of four different types, corresponding to the four types of magnets.

The main characteristics of the correction dipole magnets appear in the following table:

Magnet type	MCV	MCH	MCVA	MCHA
Maximum magnetic field (T)	0.038	0.063	0.062	0.080
Gap (mm)	200	102	200	102
Length of yoke (mm)	400	400	400	400
Mass of yoke (kg)	65	88	65	88
Mass of coil (kg)	43	33	50	33
Number of turns in coil	2420	2050	1980	1300
Maximum excitation current (A)	2.5	2.5	5.0	5.0
Maximum power dissipation (W)	160	150	320	210
Peak test voltage to ground (kV)	2.0	2.0	2.0	2.0

The CERN drawings listed in section 1.6 show the lamination, excitation coil and general assembly, respectively for each type of correction dipole magnet.

1.3 Scope of the tender

The tenderer is asked to submit an offer for the manufacture, inspection, testing and delivery to CERN, Meyrin of:

one prototype and 178 correction dipoles of the MCV type,
one prototype and 170 correction dipoles of the MCH type,
one prototype and 82 correction dipoles of the MCVA type,
one prototype and 66 correction dipoles of the MCHA type,

in accordance with this specification which will form part of the contract. The magnets will be delivered completely assembled and ready to go into service.

1.4 Outline of production schedule

Reference is made to § 7 of the Tender Form.

1.5 Inspection and test requirements

Representatives of CERN shall have the right to visit the manufacturer's facilities or those of his sub-contractors involved in this work, at any time, to review progress and witness specified tests.

CERN shall be given two week's advance notice of tests and inspections to be performed under the provisions of this specification. Representatives of CERN shall have the right to witness any or all of these, at CERN's discretion.

Written certified reports shall be prepared by the manufacturer for all tests and inspections and must arrive at CERN prior to shipment of the corresponding units.

1.6 Construction drawings and responsibility of the manufacturer

Prior to starting production, the manufacturer must send two complete sets of construction drawings to CERN for approval. However, the manufacturer must accept full responsibility for the adopted design and production methods and for the completed dipole magnets to conform to the tolerances, tests and requirements specified herein.

The following drawings are part of this specification:

Fig. 1	Lamination, MCV/MCVA	LEP 620 MCV 1006.3
Fig. 2	Lamination, MCH/MCHA	LEP 620 MCH 1006.3
Fig. 3	Coil, MCV	LEP 620 MCV 1007.1
Fig. 4	Coil, MCH	LEP 620 MCH 1007.1
Fig. 5	Coil, MCVA	LEP 620 MCV 1008.1
Fig. 6	Coil, MCHA	LEP 620 MCH 1008.1
Fig. 7	General assembly, MCV	LEP 620 MCV 0007.0
Fig. 8	General assembly, MCH	LEP 620 MCH 0007.0
Fig. 9	General assembly, MCVA	LEP 620 MCV 0008.0
Fig. 10	General assembly, MCHA	LEP 620 MCH 0008.0

CERN reserves the right to make small changes to the drawings by the time the contract is placed.

1.7 Packing and transport

It will be the responsibility of the manufacturer to arrange for safe and efficient transport and delivery of the magnets to CERN.

1.8 Provisional acceptance

Each magnet will be excited at maximum current and tested magnetically at CERN. Should these tests reveal any defects due to faulty construction, damage during transport, or failure of the magnet to meet the specified mechanical tolerances and electrical tests, CERN will be entitled to the urgent repair or replacement of the faulty part(s) free of charge.

1.9 Late deliveries

The manufacturer shall closely follow the delivery profile which will be stipulated in the contract so as not to perturb the subsequent operations on the correction dipoles at CERN. A tolerance of plus or minus one month of production (6 MCV, 6 MCH, 3 MCVA and 3 MCHA dipoles) with respect to this profile will be accepted. The manufacturer must not deliver magnets above the maximum limit.For the magnets delivered below the minimum limit, the penalties stipulated in § 10 of the Tender Form will be applied.

2 MANUFACTURE OF THE MAGNETIC CIRCUITS

2.1 The steel sheet

The material used for the manufacture of the magnetic circuits must exhibit both a high permeability and a low coercivity. Moreover, in view of the narrow spread in the magnetic characteristics of the correction dipoles to be achieved throughout their operating range, the uniformity of the magnetic properties of the steel sheet is essential.

These requirements can be met by non-oriented silicon steel of grade V 135-50 A according to DIN 46400, or equivalently grade FeV 135-50 HA according to EURONORM 106-71. The above standards both define magnetic, mechanical and geometrical properties relevant to punching of laminations, fabrication and operational performance of magnetic circuits.

In addition to the specifications set by the above standards, the steel sheet used must satisfy particular requirements as concerns coercivity and ageing. These requirements, and the relevant procedures for the corresponding magnetic measurements, which will be carried out by CERN, are defined in Appendix 1.

The manufacturer may choose a supply of steel in coils or in sheets, the external dimensions of which will depend on the envisaged punching procedures. These dimensions must allow a sufficient margin for accurate punching of the contour and for the removal of undesirable wedge-shaped regions at the edges.

It is the responsibility of the magnet manufacturer to purchase the necessary quantity of appropriate silicon steel from a supplier in a CERN member state. However, the supplier of the steel has to obtain CERN's approval. Prior to this approval, the proposed steel supplier must deliver to CERN samples of the proposed steel, which will be measured magnetically at CERN.

2.2 Punching of the laminations

The dimensions of the laminations and the required tolerances are shown in figures 1 and 2. The pole profiles are not final; CERN will communicate the final ones to the manufacturer within two months after the placing of the contract. However, CERN reserves the right to make minor modifications to the pole profiles after performing magnetic measurements on the production prototypes.

The punching procedure needed to obtain the specified accuracy is entirely the responsibility of the manufacturer; the following points must be observed:

a) the pole profile, the mating surfaces and the reference surfaces must be punched in the same operation;

b) the lamination burr must not exceed 0.02 mm. Any eventual deburring operation must not damage the punched profile;

c) care must be taken to avoid distortion or damage to the laminations in handling, transport and storage; any distorted lamination must be rejected.

Before the series production of the punched laminations can start, the dimensional tolerances must be checked in the presence of a CERN representative. This will be done by punching a number of laminations and measuring three of each type. The manufacturer must have adequate facilities for these measurements.

The manufacturer shall inspect laminations from the production runs frequently enough to monitor the performance of the dies. After each re-sharpening of a die, three laminations shall be fully measured by the manufacturer and the results communicated to CERN. CERN reserves the right to take sample laminations for inspection every 4000 laminations and after each re-sharpening of a die. If any of these fail to meet the specified dimensions and tolerances, all laminations punched since the last accepted sample laminations may be rejected.

2.3 Construction of the stacks

The laminations must be thoroughly cleaned, degreased and freed from all traces of organic solvent. They shall be stacked in a rigid jig, put under compression and glued together using a thermosetting epoxy resin, in order to obtain rigid stacks constituting half-yokes of the magnets. The stacking jig must confine the laminations against suitable reference surfaces, so as to ensure that the pole, mating surface and external reference surfaces are as smooth as possible. Therefore privileged stacking references are pole profile, mating surface and external reference surfaces. In order to avoid stresses in the stacks, overdetermination of these stacking references should be avoided. The contacts between stacked laminations and reference rulers should also be limited to a small area.

The stacking pressure shall be determined by the manufacturer, depending on yield strength, flatness and burr of the laminations. However, a packing factor (see § 2.4) exceeding 0.94 must be achieved.

The manufacturer shall make sure that the laminations are uniformly distributed over the length of the stack, and that all laminations are in contact with the reference surfaces of the stacking jig.

The glueing process, as well as the subsequent curing process using a suitable thermosetting epoxy resin, are left to the responsibility of the manufacturer, who shall however comply with the following rules:

a) the laminations shall be glued only once they are properly held in the stacking jig and a suitable compressive force applied;

b) the epoxy resin used must comply with the requirements of resistance to ionizing radiation defined in Appendix 2;

c) the viscosity of the resin as well as the glueing process must ensure thorough penetration of the resin between the laminations.

The tenderer is asked to give a precise description of the glueing process he proposes.

Before production starts, the manufacturer will have to demonstrate the quality of the proposed glueing process, by supplying CERN with twelve full-scale sample stacks (six of the MCV/MCVA type and six of the MCH/MCHA type). Each sample stack will undergo a rupture test in flexion, performed by applying a vertical concentrated load to the middle of the stack, supported on its two ends. In all cases:

a) the rupture load must be greater than 50 kN; (5000 kgf)

b) the penetration of the resin, as observed on the fracture surfaces, must have occurred over at least 10 mm all around the external contour of the laminations.

The series production of the stacks can only start once the glueing process has been approved by CERN, on the basis of the above tests.

Moreover, in order to ensure constant quality of the glueing process throughout production, CERN reserves the right to renew the above tests on series stacks taken from the production line, up to a maximum of 20 stacks.

After glueing and curing, each stack, which must then behave as a rigid block, will be extracted from the stacking jig, and its pole profile, mating surface and reference surfaces cleaned from any excess resin without damage. The resistance of each stack to shear shall be systematically tested (see § 2.4).

Each stack shall be given a serial number, permanently marked in a clearly visible place.

2.4 Mechanical tolerances and tests on the stacks

The packing factor, defined as the total mass of the laminations in the stack divided by the mass of steel of a volume equal to that of the stack, must be greater than 0.94.

The exact value of the packing factor and the corresponding nominal mass of laminations shall be determined during the assembly of the first stack of each type. The packing factor of all following stacks must be equal to the first one to within ± 0.5 %.

The length of each finished stack measured in the proximity of the pole and mating surfaces shall be 400 ± 0.2 mm.

The straightness of each finished stack, checked along the mating and reference surfaces, shall be within ± 0.05 mm. The pole surface shall be flat to within ± 0.05 mm.

The perpendicularity of the end faces with respect to the poles must be within ± 0.2 mm.

500 kgf

The mechanical resistance to shear and flexion of each finished stack shall be tested by applying to the middle of the stack, supported on its two ends, a vertical concentrated load of 5 kN. No sign of degradation or permanent deformation should be observed. The details of this test will be agreed between CERN and the manufacturer.

All results of the above mentioned measurements and tests must be recorded together with the serial number of the stack.

2.5 Finishing of the stacks

Because of the possible nitric acid content (about 10 ppm) of the ambiant air during operation, the protection of the magnetic circuits against corrosion is of utmost importance.

After having verified all geometrical tolerances, the stacks, except for the mating surfaces, the external reference surfaces and the parts of the shim surfaces supporting the magnetic circuit spacers, must be painted with at least one coat of a suitable primer and two coats of a high-grade radiation-resistant epoxy paint. At an integrated radiation dose of 10^7 Gy (10^9 rad), the painted surfaces must not show any degradation such as fissures or blisters. The type, quality and colour of the paint must be chosen in agreement with CERN.

Before applying the primer, it shall be verified that no burrs or metallic chips are left on the magnetic circuits.

All unpainted surfaces must be protected against corrosion with a radiation-resistant grease (e.g. of the type SHELL APL 700 or CASTROL NUCLEOL).

3 FABRICATION OF THE EXCITATION COILS

3.1 The conductor

The coils must be wound with enamelled copper wire of round cross-section having the following characteristics:

a) material : annealed electrolytic copper of electrical grade with an electrical resistivity below $1.76 \times 10^{-8}\,\Omega m$ at 20°C;

b) nominal diameter : 1.6 mm for the MCV coils,
1.5 mm for the MCH coils,
1.9 mm for the MCVA and the MCHA coils;

c) insulation : polyamide-imide enamel of grade 2 thickness, thermal class H.

The wires should conform to the requirements of standard IEC 317.

It is the responsibility of the manufacturer to purchase the necessary quantity of appropriate copper wire from a supplier in a CERN member state. Copies of the technical certificates of the wire shall be supplied to CERN before coil winding begins.

3.2 Coil winding

The number of turns per coil must be
2420 for the MCV coils,
2050 for the MCH coils,
1980 for the MCVA coils,
1300 for the MCHA coils.

Each coil must be wound with one conductor length; no joint is allowed in any of the coils.

The manufacturer must ensure that the winding method and techniques employed achieve a filling factor of about 0.70, and guarantee the dimensional tolerances of the finished coils. For this purpose, it is suggested to wind the coils on formers made of epoxy-impregnated glass-fibre laminates, which, after impregnation, will become integral parts of the coil assemblies.

In each case, the terminal wires must come out of the coil assemblies as shown in the corresponding drawings; these wires must be covered by epoxy-impregnated glass-fibre sheaths for mechanical protection and electrical insulation; their free length must be sufficient to allow easy connection to the magnet terminals at the final assembly stage.

3.3 Coil impregnation

After winding, a glass-fibre tape of the appropriate width is wrapped around each coil assembly. This tape must provide the required ground insulation (see § 3.5) between the heat sink and the coil.

The glass-fibre must be of the E-type and have a surface finish suitable for its bonding with the impregnating resin. All empty spaces must be filled with a suitably shaped glass-fibre laminate and/or glass-fibre having a good adhesion to the impregnating resin. Overthicknesses of non-reinforced resin exceeding 0.5 mm are not allowed.

In order to obtain good mechanical, thermal and electrical characteristics, all coils must be thoroughly impregnated with a suitable radiation-resistant thermosetting epoxy resin.

Coil types MCVA and MCHA, which are water-cooled, must be impregnated under vacuum in order to ensure imperviousness to water which could condense on their surfaces.

Coil types MCV and MCH, which are air-cooled, do not require vacuum impregnation. The choice of a suitable impregnation process is left to the responsibility of the manufacturer, who will give a precise description of the proposed process and justification of his choice.

In all cases, the choice of impregnation resin, curing agent, accelerator and curing schedule are the responsibility of the manufacturer. However, he shall observe the following points:

a) it is essential that the resin complies with the requirements of resistance to ionizing radiation defined in Appendix 2;

b) all components of the resin system must come from the same firm;

c) the viscosity of the resin as well as the impregnation process must ensure thorough penetration of the resin between the turns of the winding;

d) after impregnation and curing, each coil must behave as a rigid unit under the action of electromagnetic forces and thermal stresses arising in operation.

The manufacturer will explain to CERN on which criteria he has based the choice of impregnation resin and curing schedule.

The heat-sink (see § 3.4) is then glued, using a thermosetting epoxy resin complying with the requirements of Appendix 2, on the coil assembly, of which it will become an integral part; good mechanical and thermal contact must be ensured.

3.4 The heat sinks

In operation, the power dissipated by each coil will be extracted from the coil surface by a heat sink.

Coil types MCV and MCH are equipped with natural convection air-cooled heat sinks, which consist in finned extruded profiles made of aluminium alloy with a black anodized surface treatment. The total height of the profile (i.e. fin and base plate) must be between 30 and 40 mm, and the fin orientation must be such that it allows maximum cooling efficiency.

Coil types MCVA and MCHA are equipped with water-cooled aluminium heat sinks, which can be made out of extruded profiles. The cooling duct must have an inner diameter of 4 mm, and must withstand internal pressures up to 25 bar.The inlet and outlet terminations of the cooling duct must come out of the coil assembly as shown in figures 5 and 6. On each finished coil and heat sink assembly, the manufacturer shall ensure that the water circuit is clean, unobstructed and leak-tight (see § 3.5).

In all cases, the heat sink must be in good thermal and mechanical contact with its coil. It must fit the coil snugly, so that the amount of resin between them is as small as possible. In order to ensure good adhesion to the resin, the contact surfaces of the heat sinks shall be degreased, sandblasted and freed from all traces of organic solvents.

3.5 Tests on the finished coils

Each coil shall be given a serial number, permanently marked in a clearly visible place. The results of all tests on each coil shall be recorded together with its serial number. Coils which fail any of the described tests will be rejected by CERN and will have to be satisfactorily repaired or replaced by new ones, free of charge.

3.5.1 Mechanical tolerances

For each coil, the toleranced dimensions indicated in the relevant drawing shall be measured by the manufacturer, using an appropriate jig, which allows to check immediately if the coil may be fitted to the corresponding magnetic circuit and does not exceed the allowed overall size.

3.5.2 Hydraulic test

All hydraulic tests will have to be carried out with demineralized water only; aluminium and stainless steel are the only metals which can be used in the set-up for the hydraulic tests. The manufacturer shall make sure that the cooling ducts are never fed with tap water. According to the experience gained at CERN, aluminium cooling ducts may be severely corroded if fed with tap water which carries corrosion inducing elements such as iron oxide particles.

Each MCVA and MCHA cooling circuit shall be filled with demineralized water and pressure-tested up to 25 bar; no leak must be detected. Immediately after this test, the water remaining in the cooling circuit must be completely evacuated.

3.5.3 Electrical tests

a) **Electrical resistance**

The electrical resistance of each coil shall be measured at a temperature of 20°C. The acceptable range of electrical resistance will be defined in agreement with the manufacturer following delivery of the production prototypes.

b) **Insulation**

Each MCV and MCH coil shall undergo an insulation test performed by applying an a.c. voltage of 1.4 kV r.m.s., 50 Hz between the heat sink and the conductor for one minute.

Each MCVA and MCHA coil shall be completely immersed in tap water at ambiant temperature for at least 8 hours (24 hours for the prototype coils). It shall then be lifted out of the water as far as necessary to clear the terminals; the part of the coil outside the water shall be covered with a thoroughly wet cloth. An insulation test will be made with an a.c. voltage of 1.4 kV r.m.s., 50 Hz applied between the water and the conductor for one minute.

On all coils the resistance to ground will be measured before and after the a.c. test with a voltage of 1 kV d.c. The measured values must exceed $10^8\,\Omega$. Immediately after these tests, the interturn insulation will be checked. A voltage of 500 V r.m.s. must be applied between the terminals of each coil for one minute. This can be done either with a capacity discharge or by using the coil as an open secondary of a transformer. The final method will be agreed with the manufacturer.

4 FINAL MAGNET ASSEMBLY AND TESTS

4.1 Coil and magnetic circuit assembly

Each magnetic circuit is made of two identical stacks, fitted around the corresponding coil and held together by means of an aluminium alloy frame and stainless steel tie-bolts and spacers.

The precise aperture of the magnet gap is ensured by stainless steel spacers resting on the shim surfaces.

The precise transverse alignment of the stacks with respect to each other is ensured by 3 mm diameter dowel pins placed in the V-shaped grooves extending over the whole length of the stacks.

The longitudinal alignment of the stacks with respect to each other is given by the inner surfaces of the coil. Shims of adequate thickness, made of epoxy-impregnated glass-fibre laminates, will have to be inserted between coil and yoke to make up for assembly tolerances and surface irregularities.

The mechanical design and tightening of the tie-bolts must be such that they apply a compressive force of at least 2 kN between both halves of the magnetic circuits.

4.2 Mechanical tolerances on the magnetic circuits

The geometry of each assembled magnetic circuit will be checked at six significant locations (middle and ends of the magnetic circuit) on the external reference surfaces. The tolerances on magnetic circuit geometry are:

± 0.10 mm for the MCV and MCVA magnets,
± 0.05 mm for the MCH and MCHA magnets.

The longitudinal offset between the two stacks of each magnetic circuit must not exceed 0.2 mm.

4.3 Finishing of the magnets

The coil is connected to the magnet terminals, in the form of a suitable bipolar connector fulfilling the following requirements:

a) reliable crimping or brazing of the coil terminal wires;

b) resistance of the insulation pieces to ionizing radiation up to an integrated dose of 10^7 Gy (10^9 rad);

c) possibility of locking the mating connector of the feeding cable;

d) electrical insulation consistent with that of the magnet coil.

The final type of connector used must be agreed with CERN.

Each magnet shall be given a serial number, permanenty marked in a clearly visible place.

4.4 Tests on the finished magnets

The electrical resistance will be measured at the terminals of each magnet at a temperature of 20°C; it must be equal within ± 1 % to that measured on the coil alone.

The electrical insulation between coil and magnetic circuit will then be tested by applying a 1 kV d.c. voltage for one minute between the magnet terminals and the grounded magnetic circuit: the leakage current must not exceed 10 μA.

4.5 Inspection report

An inspection report must be supplied with each magnet. It shall include:

a) the serial number of the magnet,

b) the serial number of each stack and of the coil,

c) the inspection report of each stack (§ 2.4),

d) the inspection report of the coil (§ 3.5),

e) the inspection report of the assembled magnet (§ 4.2),

f) the results of the tests on the finished magnet (§ 4.4).

APPENDIX 1 : MAGNETIC PROPERTIES OF THE STEEL SHEET

A1.1 Type of steel

The material used for the manufacture of the magnetic circuits is a non-oriented silicon steel of grade V 135-50 A according to DIN 46400, or equivalently grade FeV 135-50 HA according to EURONORM 106-71.

A1.2 Coercivity

The coercivity hereafter specified is the value of the magnetizing field which reduces the induction in the steel to zero from the value existing after an excitation greater than 5000 A m^{-1}. The values of coercivity for the whole steel delivery must remain within ± 5 A m^{-1}. The nominal value, which shall be less than 40 A m^{-1}, is normally met by the type of steel defined above.

A1.3 Ageing

In principle, the steel supply should be entirely stable with respect to time in both coercivity and permeability. As a practical criterion, it is proposed that the ageing properties of the steel sheets are evaluated by remeasuring the coercivity after 100 hours accelerated ageing at 150°C on samples from full-scale production. The values measured on the aged samples should not exceed those measured before accelerated ageing by more than 5 A m^{-1}.

It is not proposed to perform systematic ageing tests throughout the production, but is is expected that the constancy of the ageing properties will be ensured by the conformity of the material to the requirements of the above standards.

A1.4 Procedure for the magnetic measurements

The magnetic properties of the steel will be tested by CERN by systematic measurements on samples taken throughout the delivery.

The samples, each of which consists of twelve plates of dimensions 140 mm x 140 mm, will be taken from "test units" ("unités de réception") as defined in DIN 46400 or equivalently EURONORM 106-71.

The precise number of tests units, and hence the total number of samples will be fixed once the size and number of coils, and the form of delivery have been agreed between the manufacturer and the steel supplier.

It may be expected that the number of samples required will be of the order of 100. A representative of CERN may be present for the choice and preparation of the samples.

The steel samples will be cut at the steel supplier's to rings of 76 mm inner diameter and 114 mm outer diameter bearing a reference mark of the rolling direction and sent to CERN for the measurement of their magnetic properties. In order not to spoil the magnetic properties of the steel, the rings must be cut at low speed (e.g. on a lathe or by a special machine tool). Punching is not acceptable.

No steel can be delivered to the magnet manufacturer until the corresponding samples have been magnetically tested at CERN.

It is proposed that the results of the measurements by CERN shall be submitted to the contractor. Unless an objection is made within fourteen days after receipt of the data, it will be assumed that the contractor is in agreement with the results. Subsequently, these results will be used for the purpose of acceptance or rejection. In the event of an irresolvable dispute about the results of the measurements, a neutral institution will be required to arbitrate.

A1.5 Tolerances on magnetic characteristics measured on samples

It is desirable that from any test unit no sample should show magnetic characteristics outside the limits stated in sections A1.2 and A1.3.

CERN reserves the right to refuse acceptance of a test unit which exhibits unsatisfactory magnetic characteristics.

CERN is willing to perform magnetic measurements on silicon steel samples supplied by the tenderer at any time during the tendering period.

APPENDIX 2 : RADIATION RESISTANCE OF THE EPOXY RESINS

The glued magnetic circuits and impregnated excitation coils will have to operate in the presence of ionizing radiation and at temperatures above the ambient which may range up to 60°C. Therefore, it is essential that the epoxy resins used in their construction exhibit good resistance to radiation and to its synergetic effects with temperature.

As a practical criterion, it is required that the flexural strength measured on irradiated samples of the resins, after being exposed to an integrated dose of 10^7 Gy (10^9 rad), is not less than 50 % of the value measured on non-irradiated samples.

The tenderer must send to the person technically in charge, by separate mail, samples of the resins he intends to use (enough for 30 specimens 80 mm x 10 mm x 4 mm per resin). If the tenderer has already submitted resin specimens to CERN in connection with previous tenders or contracts, to which he shall make reference, it will not be necessary to send the sample sheets mentioned above.

CERN can give advice for the selection of radiation-resistant materials and insists on being completely informed about the composition, curing cycle, curing temperatures and other relevant properties of the proposed resins, like viscosity and pot life as a function of temperature.